PROGRESS REPORT 6

AUTOMATIC PHOTOINTERPRETATION FOR LAND USE MANAGEMENT IN MINNESOTA

ERTS

Proposal Number MMC 257

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Summary

The lake acreage study was completed. The results are described in the attached report. Primary conclusions are:

1. The ERTS band 7 density range of 0-5 reliably indicates open water down to 2 acre size.

2. The density range 6-9 identifys swamps.

3. The depth of the water could not be determined.

4. Cloud shadows can be misread as lakes unless the clouds are detected.

5. ERTS data would provide the information for classifying lakes and for monitoring fluctuations in lake area.

RAMSEY COUNTY LAKE STUDY

An Application of ERTS-1 Data for the
Determination of Lake Acreage

Introduction and Purpose

The purpose of the following report is to evaluate the reliability of using ERTS-1 imagery for the determination of lake acreage. The study was run using Ramsey County as the test area due to the availability of a clear ERTS photo and easily accessible ground truth data.

While some lake related studies require extensive amounts of information from various sources, many uses can be made of mere area measurements.

A simple inventory of water resources can be of great value in determination of water resources, recreational areas, and storage capabilities. Normally, this would be done from aerial photos which are costly, time consuming, and, therefore, not taken often. ERTS photos offer, potentially, an 18-day inventory updating system. This information could also be used to improve the water information on county highway maps. It is not unusual for existence, size, location, and/or shape of a lake on these maps to be erroneous.

More rapid changes can only be observed by chance or by a device such as the ERTS photos. These involve changes in shoreline and lake size due to natural processes and development, or the side effects of development. The resulting changes can effect waterfowl, fish and also legal matters: The bringing of unused shallow lake lands into productive use involves a taxation change on that land.

The monitoring of changes in lake levels and lake occurrences is also of great value in developing an index of annual waterfowl production. Canadian and U. S. biologists suggested that a reliable production index could be derived independent of size of the breeding population from estimate of the number of ponds remaining in mid-July (1). Automatic data processing of changes in wetness during the May - July period would provide this.

Procedure

For this study, a print out of the band 7 light intensity data was used. Since each data point is approximately equal to 1.5 acres on the ground, one had only to count up a certain grouping of numbers and multiply the obtained total by a correction factor. To account for element overlap along the scan lines, the expression 1.104N + .453L was used to convert the number of elements to acres. In the expression, N is the number of elements and L is the number of scan lines involved.

After comparing the shapes of several lakes on the computer print out with their respective shapes on topographic maps, the arbitrary interval of 0 through 5 was selected as being indicative of water on band 7. The acreage of each lake in Ramsey County was then merely counted and compared with available data on basin and lake acreage.

For the lakes for which depth measurements were available, the interval of 0 through 1 was, again arbitrarily, selected and the acreage within the lake on the computer print out counted. The figures obtained were then compared with the data on depth.

It should be pointed out that the arbitrariness of the interval selections has absolutely no bearing on the accuracy of the study; for, if the method of calculating acreage is valid, any error in the choice of an interval should produce consistant errors in acreage, i.e., consistantly too high or consistantly too low.

The information thus obtained and comparisons with available data are provided on pages 3 through 8. Any lakes in Ramsey County not included in this study did not fall within the area pulled from the ERTS photo.

Results and Comments

A glance at the counted acreage as compared to basin acreage and lake acreage reveals that, in most cases, the counted acreage provided a good measure of the actual acreage. The comments and lake types included are an attempt to account for the discrepancies that do arise. A check of these and a brief discussion should make quite clear the fact that the technique is a good one.

ke no.	name	counted acreage①	basin acreage②	lake acreage③	acres ≥ 10'④	counted acres ≥ 10'⑤	type⑥	comments⑦
2-1	Silver	60.68	68	73			V	seems to match exactly the 5' contour
-4	Pigs Eye	547.91	511				IV	much swamp to east & south
-5	Caseys	8.02	14				VA	basin slightly larger, mainly open water
-6	Kohlman	72.07	84				VA	basin (depression) larger
-7	Gervais	205.07	234	206	135	138.75	V	basin larger than lake surf.
-8	Savage	17.32	46				IV	I35E now cuts through lake; ba much larger than water area; reeds & emergent vea.
-9	Round	10.24	14				VA	basin larger than actual lak.
-10	Keller	70.93	72				VA	basin larger
-11	Wakefield	15.58	23				VA	1/5 shoreline is marsh; basin slightly larger
-12	Round	18.01	23				V	marsh in area to north the appears to be basin
-13	Phalen	191.09	193	192	124	127.65	V	basin slightly larger
-14	no name	6.91	18				VA	basin larger than water area; marshes to NW & SE
-15	Sandy	not visable	22				VA	sludge basin, St. Paul water supp

lake no.	name	counted acreage ①	basin acreage ②	lake acreage ③	acres ≥ 10' ④	counted acres ≥ 10' ⑤	type ⑥	comments ⑦
62-16	Beaver	68.91	65				VA	marsh to NE; small bit to south
-17	no name	17.35	24				IV	marshy & swampy
-19	Black	9.78	120				IV	surrounded by marsh; eliminated by air photo
-20	no name	3.78	22				IV	eliminated by air photo
-21	Tammarack	1.56	69				III	eliminated by air photo
-22	no name	1.56	10				VA	marsh, inaccessible
-23	no name	not visable	14				VA	swamp
-24	Birch	107.56	127				VA	96 - county road 6 - now goes through southern end
-25	Ox	7.36	13				VA	pond, swamp, some open water; 96 - county road 6 goes through
-26	no name	5.80	12				IV	southwestern & northwestern shores - marsh, narrow strip connecting top & bottom
27	Gillfillan	89.80	87				VA	
28	Sucker	56.70	59	60	12	25.53	V	St. Paul Water Supply
29	Basswood	not visable	110					

ake no.	name	counted acreage①	basin acreage②	lake acreage③	acres ≥10'④	counted acres ≥10'⑤	type⑥	comments⑦
62-30	Lambert	not usable	542				III	eliminated by air photo
-31	Grass	not usable	84				III	eliminated by air photo
-32	Rice	1.563	121				III	eliminated by air photo
-33	no name	not usable	87				IV	eliminated by air photo
-34	Goose	122.64	152				VA	US 61 goes through
-35	no name	2.67	10				IV	eliminated by air photo
-36	Priebe	3.13	17				VA	narrow; surrounded by houses now; used as neighborhood pond
-37	Gem	16.24	20				VA	marsh at SE end, basin s ly larger than lake
-38	Vadnais	568.52	477				V	marsh in SW & NE has water print out, also water seper from lake in marsh; road-th too narrow to show; St. Paul wa
-39	Twin	25.12	37	35	25	12.21	V	some marsh to SE & NE
-40	Willow	30.47	75				IV	surrounded by marsh, basi (depression) much larger than water surface
-41	no name	8.02	15				VA	surrounded by marsh; ve shallow, some constructio one side & homes; basin l
-42	no name	6.91	12				VA	basin slightly larger

lake no.	name	counted acreage ①	basin acreage ②	lake acreage ③	acres ≥ 10 ④	counted acres ≥ 10 ⑤	type ⑥	comments ⑦
62-45	Long	4.24	111				III	eliminated by air photo
-46	Pleasant	553.88	585	627	369	376.29	V	marsh at northwestern end
-48	Bennett	19.57	41				III	surrounded by marsh; eliminated by air photo
-49	Langton	16.28	35				IV	surrounded by rushes, some open water, emergent veg
-50	Wilson	1.56	19				IV	eliminated by air photo
-51	Robinson	3.78	28				II	eliminated by air photo
-52	Poplar	1.56	19				IV	eliminated by air photo
-53	no name	9.13	15				VA	exit ramp from route 36 to route 51 cuts into; some marsh, golf course on east; housing to north
-54	McCarron	62.20	71	70	50	44.90	V	a little marsh in NW, basin slightly larger
-55	Como	63.36	69	72	18	7.77	VA	basin slightly larger than water surface
-56	Owasso	333.28	360	355	101	241.98	V	marsh at southern & western end; development
-57	Josephine	112.20	110	115	51	69.93	V	
-58	Little Johanna	16.24	18				V	surrounded by marsh

ake no.	name	counted acreage①	basin acreage②	lake acreage③	acres ≥10④	counted acres ≥10⑤	type⑥	comments⑦
62-59	Marsden	1.56	291				IV	eliminated by air photo
-61	Turtle	418.46	444	447	216	330.78	V	
-62	Charley	29.56	31				VA	
-63	no name	3.13	32				II	eliminated by air photo
-64	Martha	10.24	34				IV	eliminated by air photo
-65	Sunfish	7.36	12				VA	eliminated (enclosed by Twin C Arsenal)
-70	Round	100.90	122				V	
-71	Valentine	50.48	58	60	5	16.65	VA	constriction to approx. 30c at northern edge
-72	Karth	9.58	15				VA	swamp, appears to have b partially filled in
-73	Snail	138.42	175	185	25	88.80	V	small separate section in visable on print out (is very shallow w/ much veg.)
-74	Grass	1.56	146				IV	eliminated by air photo
-75	Island	14.29	63				VA	of lake highway (694) put thro upper section - some of taken
-76	Jones	8.02	28				IV	emergent veg., only small ar... open water, marsh all arou

lake no.	name	counted acreage ①	basin acreage ②	lake acreage ③	acres ≥ 10 ④	counted acres ≥ 10 ⑤	type ⑥	comments ⑦
62-78	Johanna	189.49	211	225	162	143.19	V	
-79	no name	6.46	11				VA	pond
-80	Emily	5.80	12				VA	highway along eastern lo houses on western
-81	Mud	9.13	16				VA	surrounded on western ha houses & rushes on east
-82	Wabasso	36.67	47	46	20	17.76	V	surrounded by marsh (c rushes) - about 50 yds. open water
19-79	Pickerel	94.94	52				IV	steep side to SE (causes sh marsh to S & NW towar river; RR through the t
82-167	White Bear	2383.57	2410	2479	1924	2065.71	V	

on location of lakes consult map on page 9

① number of points on computer print out in the range 0 thur 5 multiplied by 1.104 N + .453 L

② acreage of lake basin as indicated by Bull. 25, Div. of Water, Soils & Minerals, Dept. of Natural Resources, from 1949 data

③ acreage by planimetry from Div. of Water, Soils, & Minerals maps ranging in age from lake to lake

④ " " " " " " " " " " " " " " " " " "

⑤ number of points on computer print out in the range 0 thur 1 multiplied by 1.104 N + .453 L

⑥ lake type established by Metropolitan Inventory of Lakes, Dept. of Conservation, Fish & Game Commission

II - grass or sedge meadows
III - shallow marsh
IV - deep marsh
V - fish lake
VA - marginal fish - game lake

⑦ comments refer to field checking & air photo interpretation (1968 - Mark Hurd photos) done for Ramsey County lake surface zoning study and reference to topographic maps (USGS - various years)

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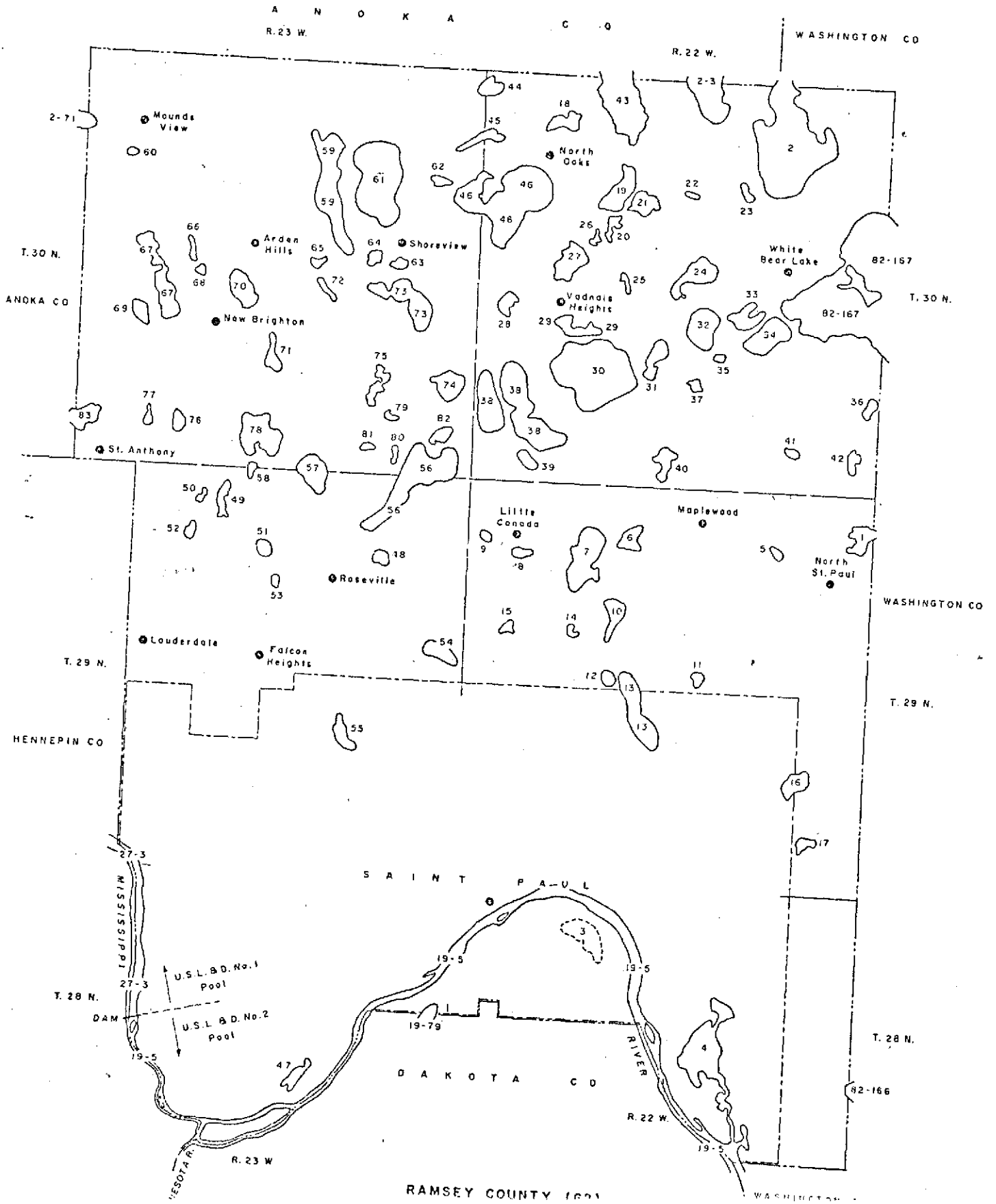
MINNESOTA CONSERVATION DEPARTMENT



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In comparing the figures, one should bear in mind that basin acreage indicates the area of the basin, i.e., the depression, not the actual area that contains water. Likewise, the lake acreage includes most marsh areas around the lake, not just areas of open water. The chosen interval of 0 through 5, on the other hand, seems to indicate only open water, or water with a very slight amount of emergent vegetation or rushes. This can be seen by looking at some of the lakes indicated as eliminated by air photo in the comment column.

The phase "eliminated by air photo" indicates that a particular lake was considered to contain no open water, i.e., to be drained or swamp, from analysis of 1968 low altitude air photos of Ramsey County. As can be noted from the table, several of the eliminated lakes are shown as containing small amounts of water. These are likely lakes that contain water in only part of the year and are swamp or dry for the rest. Some of the lakes, for example 62-20, can be made to assume their exact basin shape by considering the numbers 0 through 9. This seems to imply that the lake is surrounded by detectable swamp (this lake is shown as surrounded by swamp or marsh on the USGS topographic sheet).

Other lakes, for example 62-23, indicated as swamp from field checking, are not visable at all until the interval 6 through 9 is noted. In addition, an area just north of Pigs Eye, 62-4 shows up in the interval 6 through 9 and is designated swamp on the topographic sheet. It seems, then, that this interval, 6 through 9, could be used to identify swamps.

The use of this technique for determining depth acreage in lakes is of absolutely no value. While the date shows that many of the counted and planimetric calculations are very close, this closeness is merely a factor of chance. For, a visual comparison of the areal distribution of acreage greater than or equal to 10' on the Division of Water, Soil, and Minerals maps and on the computer print out shows absolutely no correlation. This lack of correlation is likely due to such factors as sun angle and lake water pollution.

Problems in Interpretation

One problem encounted in this study was that things other than water fell in the interval 0 through 5. Along with water

were cloud shadows and heavily industrialized areas. It seems, however, that consideration of band 5, which enhances cultural features, will enable the elimination of those areas in the interval 0 through 5 which are not water. On band 5, the heavily industrialized areas seem to show up as much lower numbers than the lakes. Cloud shadows can be distinguished by locating the cloud. By looking in the appropriate direction, given the time of day of the photo and the time of year, one encounters an area, somewhat smaller than the cloud shadow, of very high numbers, higher than any thus far encountered in this study. Thus, by scanning the photo, cloud shadows can be distinguished from water. Alternatively, photos from different dates could be compared; for, the probability of a cloud being in the same position from one date to another is very slim.

Another problem may be that of loss of data between print out sheets. Sandy Lake, 62-15, which is not visable, seems as if it should fall on the intersection of four sheets. It is also likely that 62-15 was nearly dry at the time of the photo; for, it is a water supply lake and, therefore, highly fluctuating.

It seems that lakes down to a two acre size can be located by this technique. This is a much better performance than that obtained by a visual mapping project conducted by the Department of Geography of the University of Minnesota. They had approximately a ten acre threshold viewing size for small water bodies. They also noted difficulties in the discrimination of lakes and cloud shadows and of lakes and freshly plowed fields (2). The latter difficulty was not encounted in this study due to the lack of agriculture in Ramsey County.

Conclusion

In conclusion, it seems that the technique of determining and monitoring lake acreage would provide adequate information for the various purposes discussed in the introduction, as well as others.

Numerous water areas not designated as lakes, perhaps due to their periodic nature, were noted on the computer print out. These corresponded to areas of water or swamp on the USGS topographic maps. Since the appearance of lakes is, generally speaking, a reflection of the ground water level, water fluctuation in a swamp area of known elevation could be used

to calculate the water table fluctuation, either due to natural causes or human intervention, throughout the year, as well as just the level of lakes themselves. This information when combined with other information dealing with inflow and outflow from a lake by surface systems would enable the determination of mass budgets for lakes.

This acreage calculation method could also be valuable in the typing of lakes. A comparison of counted acreage with basin acreage and counted acreage from 6 through 9 could lead to a useful classification of lakes. Jack Flynn, working on the Ramsey County Lake Surface Zoning Study for the Minnesota Land Management Information Systems Study, felt that this computerized evaluation technique would be of great value to the classification of lakes. For, some lakes not eliminated by air photo, were discovered to be marsh on field checking. Others were discovered to be inaccessible due to being completely surrounded by marsh. A computerized evaluation using ERTS data rather than old aerial photos would have lead to efficient use of costly, time consuming field work.

Continued Studies

The study thus conducted used map and aerial photo information for comparison and ground truth because it was all that was available. Currently, the Department of Geography of the University of Minnesota is working on the determination of lake acreage as well as location and shape from ERTS photos. A comparison of their results with the ones obtained by automatic techniques would prove invaluable in the determination of which technique yields the best result with the least effort.

As yet, their study does not include the Ramsey County area. Hopefully they will expand their study or we ours so that a comparison of results can be made.

LITERATURE CITED

1."Preliminary evaluation of ERTS-1 for determining numbers and distribution of Prairie Ponds and Lakes"; Edgar A. Work, Jr., Environmental Research Institute of Michigan; David S. Gilmer and A.T. Klett, Bureau of Sport Fisheries and Wildlife Northern Prairie Wildlife Research Center.

2. "Application of ERTS-1 Imagery to State-Wide Land Information System in Minnesota", ERTS-1 Application to Classification and Mapping of Water Resources in Minnesota; Dwight A. Brown, Ralph Sanders, Jack Flynn, and John Harrington, Department of Geography, University of Minnesota.